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ATOMIC NUCLEI[1]

I. INTRODUCTION

THE conception that atoms consisted of central positively charged nuclei of small dimensions surrounded by one or more systems of electrons whose aggregate charge of negative electricity exactly neutralized the nuclear positive charge, arose in an attempt by Rutherford[2] to explain the large angle scattering of α rays obtained when these traversed thin foils or sheets of various metals.

To account for the results obtained it was found necessary to assume that the positively charged nucleus contained nearly all the mass of an atom and that the dimensions of the nucleus were very small compared with the ordinarily accepted magnitude of the diameter of the atom.

On this view the electric field close to the nucleus was very intense and therefore sufficient to deflect α particles which in traversing sheets of metal happened to pass close to nuclei.

Assuming the electric field of nuclei to be central and to follow the inverse square law, Rutherford showed that an α particle projected so as to pass close to the nucleus of an atom would describe a hyperbolic orbit about the nucleus and that the magnitude of the deflection impressed upon it was determined by the closeness of its approach to the nucleus.

(*a*) The electric charge on nuclei.

On this theory Rutherford showed by deductions made from observations on the single encounter large angle scattering of α rays that the resultant charge on the nucleus was about $\frac{1}{2}$ A e where A is the atomic weight of the

[1] Address of the vice-president and chairman of Section B—Physics, the American Association for the Advancement of Science, Toronto, December 29, 1921.

[2] Rutherford, *Phil. Mag.*, Vol. 21, p. 669, 1911; *Phil. Mag.*, Vol. 27, p. 448, 1914.

scattering element and e is the fundamental unit of electric charge. Elaborate experiments by Geiger and Marsden[3] on the scattering of α rays confirmed this view. The validity of the theory was also established in a convincing manner by C. G. Darwin[4] who made a thorough mathematical investigation of the deflexions which could ensue from an intimate encounter between an alpha particle in motion and a nucleus. In this investigation he showed that the results of the scattering experiments of Geiger and Marsden could not be reconciled with any law of central force except that of the inverse square.

In another entirely different field of investigation, namely, that of the scattering of X rays by light elements, Barkla[5] had shown in 1911 that the number of electrons in an atom which took part in the scattering of the X rays was equal to about one half of the atomic weight of the element.

Both lines of investigation therefore led to the view that the charge on the nucleus of an atom was given by ½ A e and that the number of electrons in an atom surrounding the nucleus was ½ A. It was the experiments on the scattering of α rays, however, which led to the view that the positively charged portions of atoms were nuclear in character with dimensions small compared with those of the atoms themselves, and that by far the greater part of the mass of the atoms was concentrated in the nucleus.

(*b*) Nuclear charge and atomic number.

In 1913 Van den Broeck[6] put forward the suggestion that the scattering of α particles was not inconsistent with the view that the charge on the nucleus of an atom was equal to Ne where N is the atomic number of the atom of the element concerned, *i. e.*, the number of the element when the elements are arranged in order of increasing atomic weight. A reference to a table of atomic weights will show that N is approximately equal to ½ A. The importance of this suggestion was soon made evident by the remarkable work of Moseley[7] on X ray spectra which followed in 1913 and in 1914. In this work Moseley showed that the frequencies of the vibrations of corresponding lines in the X ray spectra of the elements depended on the squares of numbers which varied by unity with the successive elements.

This relation, it was seen, could be readily explained by assuming that the nuclear charge of an atom varied by unity in passing from an atom of one element to that of another, and by assuming that the nuclear charge was given numerically by N, the atomic number.

The importance of Moseley's work was enhanced when it was seen that it gave us a new method of regarding the periodic classification of the elements based on the assumption that the atomic number or its equivalent, the nuclear charge, was of more fundamental importance than the atomic weight. As a result of Moseley's work it became possible not only to fix definitely the number of possible elements and the position of undetermined elements, but also to show that the properties of an atom were defined by a number which varied by unity in successive elements.

In Moseley's work the frequency of vibration of corresponding lines in the X ray spectra of the elements was not found to be exactly proportional to N^2 where N is the atomic number but to $(N - a)^2$ where a was a constant which had different values depending on whether the K or L series of characteristic rays was measured.

The investigations of Bohr[8] on the origin of radiations emitted by atoms are entirely in keeping with the assumptions that the nuclear charge is given by Ne, for he has shown that the frequency formula for X ray spectral lines must include a term $(N - a)^2$ with "a" having values approximately equal to those found by Moseley. In Bohr's investigation he showed that X rays originated in disturbances given to certain classes of extra nuclear electrons and that the quantity "a" represented a modifi-

[3] Geiger and Marsden, Roy. Soc. Proc. A., Vol. 82, p. 495, 1909.

[4] Darwin, *Phil. Mag.*, Vol. 27, p. 499, 1914.

[5] Barkla, *Phil. Mag.*, Vol. 21, p. 648, 1911.

[6] Van den Broeck, *Phys. Zeit.*, Vol. 14, p. 703, 1914.

[7] Moseley, *Phil. Mag.*, Vol. 26, p. 1024, 1913; *Phil. Mag.*, Vol. 27, p. 703, 1914.

[8] Bohr, *Phil. Mag.*, Vol. 26, p. 476, Sept., 1913.

cation of the electric field of the nucleus by the electric fields of the extra nuclear electrons within the atom.

II. On the Structure of Atoms

Through the advances made by a study of the scattering of α rays and of X rays the attack on the problem of the structure of atoms and the origin of radiations naturally proceeded upon two well-defined lines, namely:

1. The investigation of the constitution and properties of the nucleus, and

2. The investigation of the configuration and modes of vibration of extra nuclear electrons in atoms.

In pursuing this attack it has been assumed, with very good warrant, that the positive electric charges on nuclei are given by Ne where N is the atomic number of the element concerned, and that the number of extra nuclear electrons in an atom is N. For example, the number of extra nuclear electrons in various atoms is taken to be as follows: Hydrogen 1, helium 2, lithium 3, carbon 6, fluorine 9, neon 10, sodium 11, chlorine 17, argon 18, potassium 19, etc.

III. Positive Ray Analysis

This method of analysis was devised by Sir J. J. Thomson[9] and consisted in projecting successively through an electric and a magnetic field positively charged atoms or molecules, *i. e.*, those from which one or more extra nuclear electrons had been detached. By this means he was able to show that positive atom ions can be obtained with one, two, three, and, in the case of mercury, with eight positive elemental charges.

Among other results he has been able to show that such compounds as CH, CH_2 and CH_3 can exist with a recognisable though transitory existence. He has also shown that a substance having the molecular formula H_3 and bearing a single positive elemental charge can be obtained from various sources, a result which has been confirmed by Dempster, who showed that this molecular aggregate can be obtained with a transitory existence when an electric charge is passed through hydrogen. Perhaps the most notable discovery made by Thomson, however, was that neon existed in two forms with identical chemical properties, but with different integral atomic weights, namely, 20 and 22.

This discovery was of prime importance for it pointed to the probability of the general applicability of the principle which had been already found by Soddy and others to hold with the radioactive elements, namely, that the atoms of elements consist of *isotopes, i. e.,* that we have atoms of an element with identical chemical properties, but with different atomic masses. This discovery also offered an explanation of the non-integral values found by chemical analysis for the atomic weights of many of the elements. If it turned out, assuming the atomic weight of oxygen to be 16, that the atomic weights of the isotopes of an element were integers, then the non-integral value found by chemical analysis for the atomic weight of an element would result from the element existing as a mixture of its isotopes.

IV. Isotopes

Aston,[10] Dempster,[11] and later G. P. Thomson[12] have recently greatly improved Sir J. J. Thomson's methods of positive ray analysis with the result that they have been able to separate many of the elements of non-integral atomic weight such as chlorine, magnesium, argon and mercury into *isotopes,* each of which has an integral value for its mass. Chlorine, for example, has an atomic weight of 35.5 and can be separated by the positive ray method into an isotope of weight 35, and into one of weight 37. The validity of this result has been confirmed by Harkins,[13] who succeeded

[9] J. J. Thomson: Rays of positive electricity.

[10] Aston, *Phil. Mag.*, Vol. 38, p. 707, 1919; Vol. 39, p. 611, 1920; Vol. 40, p. 628, 1920; *Nature,* March 17, 1921; May 12, 1921.

[11] Dempster, *Phys. Rev.*, Vol XI, No. 4, p. 316, 1918; SCIENCE, Dec. 10, 1920; Apr. 15, 1921; Nov. 25, 1921.

[12] G. P. Thomson, *Phil. Mag.*, Aug., 1920, p. 240; *Phil. Mag.*, Nov. 1921, p. 858; *Nature,* Feb. 24, 1921.

[13] Harkins, SCIENCE, March 19, 1920.

in separating, by diffusion, a mass of chlorine into two portions with different densities. Mercury, too, has been found by positive ray analysis to consist of a number of isotopes, probably six, with integral atomic weights 197-200, 202, 204. As a confirmation of this result Bronsted and Hevesy[14] have shown that it is possible by fractional distillation to separate mercury into two parts with different densities.

The list of the elements in so far as they have been investigated for isotopes is given in Table I. In Table II following there is also assembled the isotopes of the various radioactive elements.

TABLE I
ISOTOPES

Element	At. No.	At. Wt.	Minimum No. of Isotopes	Masses of isotopes in order of their intensity
H	1	1.008	1	1.008
He	2	3.99	1	4.0
Li	3	6.94	2	7, 6
Be	4	9.1	1	9
B	5	10.9	2	11, 10
C	6	12.0	1	12
N	7	14.01	1	14
O	8	16	1	16
F	9	19	1	19
Ne	10	20.2	2	20, 22, 21?
Na	11	23	1	23
Mg	12	24.32	3	24, 25, 26
Si	14	28.3	2	28, 29, 30?
P	15	31.04	1	31
S	16	32.06	1	32
Cl	17	35.46	2	35, 37, 39?
A	18	39.88	2	40, 36
K	19	39.1	2	39, 41
Ca	20	40.09	1	40 (39, 40, 41)
Zn	30	65.4	4	64, 66, 68, 70
As	33	74.96	1	75
Br	35	79.92	2	79, 81
Kr	36	82.92	6	84, 86, 82, 83, 80, 78
Rb	37	85.45	2	85, 87
Sr	38	87.63	2	87, 85, 88?
I	53	126.92	1	127
Xe	54	130.32	5 (7?)	129, 132, 131, 134, 136, 128? 130?
Cs	55	132.81	1	133
Hg	80	200.6	6	197-200 202, 204

[14] Bronsted and Hevesy, *Nature*, September 30, 1920.

V. DISCUSSION OF ISOTOPES

A glance at the results in Table I suggests a few observations.

(*a*) Isobares and radioactivity.

It is interesting to note that while iodine with an atomic weight 126.92 has but one isotope, 127, bromine with an atomic weight 79.92 has two, 79 and 81. Had it turned out that bromine consisted of but one isotope with weight 80 we should have had an example of an isobare, that is, an atom of one element with an atomic weight the same as that of an atom of a second element. It will be seen that one of the isotopes of krypton has an atomic weight 80.

It is also of interest to point out, as Harkins has done, that with magnesium having 3 isotopes and chlorine 2 it is possible to have nine isotopic forms of $MgCl_2$. As mercury has six isotopes there would follow the possibility of having 63 isotopic forms of Hg_2Cl_2. Similar considerations would apply in regard to other elements.

G. P. Thomson has recently found that strontium consists of two isotopes of weight 85 and 87. He failed however to find one of weight 88 or any higher number the necessity for which the atomic weight of strontium, 87.63, would seem to demand. As rubidium was shown to have isotopes of weight 87 and 85 we have in strontium and rubidium an example of isobaric isotopes, *i. e.*, the atoms of these two elements are identical in mass. As the nuclear charge of rubidium is 37e while that of strontium is 38e, it follows that the nuclei of rubidium atoms differ from those of strontium atoms only by the inclusion of one electron. This may possibly afford an explanation of the radioactivity which rubidium and its salts are known to exhibit. It has been shown that rubidium emits a soft radiation of beta particles, and since it is now generally agreed that radioactivity is a property of nuclei, it would follow that by the emission of beta rays, rubidium atomic nuclei are being transmuted into those of strontium. One should expect to find, then, strontium associated with the sources of rubidium.

TABLE II
ISOTOPES OF RADIOACTIVE SUBSTANCES

SUBSTANCE	AT. NO.	WEIGHT OF ISOTOPE					GROUP
Uranium	92	238 U_1	234 U_2				VI
Protoactinium	91	234 UX_2	230 Pa				V
Thorium	90	234 Th.	232 UX_1	230 I & UY	228 Ra.Th.	226 Ra.Act.	IV
Actinium	89	228 Ms.Th_2	226 Ac.				III
Radium	88	228 Ms.Th_1	226 Ra	224 ThX	222 Act.X		II
Emanation	86	222 Ra.Em.	220 Th.Em.	218 Act.Em.			VIII
Polonium	84	218 Ra.A.	216 Th.A.	214 Ra.C. Ac.A.	212 Th.C′	210 Ac.C′ Ra.F.	VI
Bismuth	83	214 Ra.C.	212 Th.C.	210 Ac.D. Ra.E.			V
Lead	82	214 Ra.B.	212 Th.B.	210 Ra.D. Act. B.	208 Th.D.	206 Ra.G. Ac.D.	IV
Thallium	81	210 Ra.C″	208 Th.C.″	206 AcC″			III

As potassium is also known to emit a radiation of beta particles we should expect the nuclei of atoms of potassium to be transmuted thereby into nuclei of calcium of the same weight, *i. e.,* we should expect to find that calcium consisted of two isotopes isobaric with those of potassium and therefore of weight 39 and 41. As regards this point the only evidence we have available is that furnished by the experiments of G. P. Thomson, who states that he found an isotope for calcium at 40 but with the magnetic field at his disposal it was impossible to separate lines even two units apart if such had existed for calcium. Thomson states, however, that it is certain that one or more isotopes of the weights, 39, 40, and 41 were present in his experiments. In some preliminary experiments made by Dempster an isotope of calcium was found at or near 40. He states, however, that the possibility of one of weight 39 is not excluded by his results. It will be interesting to see whether future experiments show that calcium has two isotopes of weight 39 and 41. Some additional evidence on this point might be gained by investigating the association of calcium with primary sources of potassium and its salts.

In this connection it is of interest to point out that lithium, sodium and cæsium have not been found to be radioactive. Moreover neither lithium and beryllium nor sodium and magnesium have any isotopes in common. Cæsium has been found to have but one isotope of weight 133 and although the isotopes of barium have not yet been investigated it would appear to be highly probable that, since the atomic weight of this element is 137.37, it will be found not to have any isotope isobaric with that of cæsium.

(*b*) Isotopes of cadmium.

Since the atomic weight of cadmium is 112.4 it will be seen that it will likely be found to have a number of isotopes, especially since zinc has been shown to have four and mercury six.

(*c*) Atomic weight and atomic number.

It will be noted that, with the possible exception of K^{39} and the doubtful Cl^{39} Table I does not show any other examples of *isobares.* There is a remarkable intermingling of the atomic weights and it is particularly noticeable in the case of ten consecutive integers representing the isotopes of bromine, krypton, and rubidium —Kr 78, Br 79, Kr 80, Br 81, Kr 82, Kr 84, Rb 85, Kr 86, Rb 87. This result makes it

clear that the exact order of the chemically determined atomic weights is of little significance and that the anomalies such as argon and potassium and possibly too of tellurium and iodine as well as nickel and cobalt are merely due to the unequal relative proportions of their constituent isotopes.

From a consideration of the total abundance of various elements Harkins[15] pointed out that for the great majority of possible configurations it would probably be found that even atomic weight was associated with even atomic number and odd with odd. The results given in Table I, it will be seen, support this view. Of the halogens (odd atomic numbers) all six isotopes are odd. Of the alkali metals (odd atomic numbers) seven istopes are odd and only one even. On the other hand, of the isotopes of the inactive gases (even atomic numbers) fifteen are even and but three odd. This means that in the nuclei of most types of atom the number of electrons is an even number.

(*d*) The spectra of isotopes.

In an attempt made by Harkins, Aronberg and Gale[16] to see whether any method of distinguishing between the isotopes of an element could be obtained from a study of their spectra it was found that the wavelength of the line $\lambda = 4058$ A.U. as obtained from radiolead was 0.0044 A.U. greater than that from ordinary lead. A similar result was also obtained by Merton.[17] It has been pointed out however that this difference is about one hundred times greater than that predicted on the basis of Bohr's Theory of Radiation. Loomis[18] also has drawn attention to the unexpected satellites which Imes[19] found beside each line of the HCl absorption band at 1.76μ, and which measurements of his curves show to have an average wavelength of 16.4 A.U., longer than the lines which they accompany. These satellites Loomis has shown can be accounted for by assuming them to be due to the heavier of the isotopes of chlorine of weights 35 and 37. On this basis, his calculations show that the difference between the wavelength of the main line and its satellite should be 13 A.U., which it will be seen is in good agreement with observations of Imes.

[15] Harkins, *Nature*, April 4, 1921.

[16] Harkins, Aronberg and Gale, *Jl. of the Am. Chem. Soc.*, July, 1920, Vol. 42, p. 1328.

[17] Merton, Proc. Roy. Soc., 96A, p. 388, 1920.

[18] Loomis, *Nature*, Oct. 7, 1920.

[19] Imes, *Astrophys. Jl.*, Nov., 1919.

(*e*) Structure of atomic nuclei.

By far the most important conclusion which can be drawn from the results recorded in Table I is that, with the exception of hydrogen, the weights of the isotopes of all the elements measured and, therefore almost certainly of all elements, are whole numbers, within the accuracy of the experiments—namely, about one part in a thousand. This result carries with it the possibility of greatly simplifying our ideas of mass. The original hypothesis of Prout, put forward in 1815, that all atoms were themselves built of atoms of protyle, a hypothetical element which he tried to identify with hydrogen, has been established on a new basis with the modification that the primordial atoms are of two kinds—atoms of positive and negative electricity. The unit of negative electricity, *the electron,* we have long been familiar with, but the unit of positive electricity, *which also appears to be the real unit of mass,* has remained unidentified experimentally until now as the positive nucleus of the atom of hydrogen. To this unit of mass and of positive electricity the name of "proton" has been given.

This profound modification of our views of the nature of mass has been very clearly set forth by Aston. The Rutherford atom whether in Bohr's or Langmuir's development of it consists essentially of a positively charged central nucleus around which are set planetary electrons at distances which are great compared with the dimensions of the nucleus itself. As has been stated the chemical properties of an element depend solely upon the atomic number which is the charge on its nucleus expressed in terms of the unit charge "e." A neutral atom of an element of atomic number N has a nucleus consisting of $K + N$ protons and K electrons and around this nucleus are set N electrons. The weight of an electron on the scale we are using is 0.0005 so that it may be neglected. The weight of the atom will therefore be $K + N$ so that if no restrictions are

placed on the value of K any number of isotopes is possible.

The first restriction is that excepting in the case of hydrogen K can never be less than N for the atomic weight of an element is always found to be equal to or greater than twice its atomic number.

The upper values of K also seem to be limited, for so far no two isotopes of the same element have been found differing by more than 10 per cent. of its mean atomic weight, the greatest difference is eight units in the case of krypton. The actual occurrence of isotopes does not seem to follow any law at present obvious, though their number is probably limited by some condition of stability.

Protons and electrons may therefore be regarded as the bricks out of which atoms have been constructed. An atom of atomic weight m is turned into one of atomic weight $m + 1$ by the addition of a proton plus an electron. If both enter the nucleus the new element will be an isotope of the old one, for the nuclear charge has not been altered. On the other hand, if the proton alone enters the nucleus and the electron remains outside, an element of next higher atomic number will be formed.

If both of these new configurations are possible they will represent elements of the same atomic weight but with different chemical properties. Such elements we have pointed out above are called isobares, and are already known to exist among the radioactive elements. (See Table II).

The element hydrogen, it will be noted, is unique in that its nucleus weight, 1.008, exhibits a departure from the rule of integers followed by the isotopes of all the other elements investigated. It will be noted, however, that it is the only atom in which the nucleus is not composed of protons and electrons closely packed together. It can be shown that with close packing of protons and electrons there must follow a reduction in effective mass, and that when four protons and two electrons are closely packed together as they must be in alpha particles, the nuclei of helium atoms, the resultant effective mass must be somewhat less than four times that of the hydrogen nucleus.

VI. The Dimensions of Atomic Nuclei, Their Electric Charges and Fields of Force

While phenomena connected with the scattering of α rays have led to such profound modifications in our views of atomic structure, it is of interest to note that through the agency of these same α rays we are likely to make still further advances in the problem of determining the ultimate structure of matter. Through the attacks now being rigorously pressed by Rutherford and his associates, the structure of the nuclei of atoms is slowly but steadily being revealed. Through the bombardment of atomic nuclei by α rays it has been found that the electric charges on atomic nuclei can be measured with a high degree of precision, estimates of the diameters of nuclei can be made, the field of electric force about a nucleus can be examined, and the structure of the nucleus itself can be broken down.

(*a*) Nuclear charges.

In his early experiments, Rutherford had shown from the experiments of Geiger and Marsden on the scattering of α rays that the charge on the nuclei of atoms of gold was within 20 per cent. equal to 100 e. More recently Chadwick[20] has shown by the use of direct and more refined methods that the charges on the nuclei of three types of atoms, namely, those of platinum, silver and copper, have the value of 77.4e, 46.3e and 39.3e respectively. As the atomic numbers of these elements are 78, 47 and 39, it will be seen that these results strongly confirm the view put forward by Rutherford as a result of the experiments of Moseley and others, which indicate that the nuclear charge is equal to Ne, N being the atomic number of the element.

(*b*) Nuclear dimensions and nuclear electric fields of force.

As mentioned above, Rutherford has shown by experiments on the scattering of α rays that the dimensions of atomic nuclei must be exceedingly small. For example, when high speed α particles collided with atoms of gold they were found to be turned back in their path at a distance of 3×10^{-13} cm. between

[20] Chadwick, *Phil. Mag.*, Dec., 1920, p. 734.

the centers of the α particles and those of the nuclei of the atoms of gold bombarded. This would go to show that in the case of the nucleus of an atom of gold, its radius is probably not greater than 3×10^{-13} cm. Further evidence in this direction has recently been adduced by Chadwick who found that the distance of approach of high speed α particles to the nuclei of platinum atoms was about 7×10^{-12} cm. and of low speed α particles about 14×10^{-12} cm.

In order to account for the velocity given to hydrogen atoms by collision with α particles, Rutherford calculated that the centers of the nuclei of helium and hydrogen must approach within a distance of 1.7×10^{-13} cms. of each other, assuming the law of repulsion to be that of the inverse square.

But the recoil phenomena of hydrogen atoms bombarded by α particles cannot be completely accounted for by assuming an inverse square law to hold for all distances between the centers of the α particle and the hydrogen nucleus. Rutherford suggested that roughly they could be explained by taking the α particle to be the equivalent of a plate of radius 3×10^{-12} cm. and assuming that as long as the α particle did not approach within this distance of the hydrogen nucleus, the ordinary inverse square law of repulsion held. If, however, the α particle did approach within this distance of the hydrogen nucleus a collision ensued which swept the latter straight forwards.

An attempt was made by Darwin[21] to work out the collision relations for all possible models of the α particle for which the electric fields would give integrable orbits. As a basis for this work he assumed the α particle to consist of 4 protons and 2 electrons, and found that a square nucleus in which the protons were arranged at the four corners of the square and the two electrons together at the center of the square, would give a field of force very similar to that of a bipole with collision relations roughly similar to those deduced from Rutherford's experiments.

[21] Darwin, *Phil. Mag.*, Vol. 41, p. 486, March, 1921.

This model has been put to the test by Chadwick and Bieler[22] and by McAuley[23] in a new series of investigations on collisions between particles and hydrogen nuclei and has been found to be not entirely satisfactory. In these experiments the earlier observations made by Rutherford were confirmed, namely, that α particles and hydrogen nuclei in collision do not behave as point charges. Not only is the angular distribution of the projected hydrogen nuclei different, but the numbers projected at small angles are for α particles of high velocity many times greater than those for point nuclei. For example, the observed number of hydrogen nuclei projected within 30° of the direction of incident α rays of range 8.2 cm. is more than 100 times as great as the theoretical number. The number projected within the same angle by α rays of range 4.3 cm. is 15 times the theoretical number. Also the observed variation of the numbers of projected hydrogen nuclei with velocity of the α particle is in the opposite direction from that given by the point theory. For example, α rays of range 8.2 cm. project within an angle of 30° nearly 3 times as many hydrogen nuclei as α rays of range 4.3 cm. On the basis of the point charge theory the α rays of 4.3 cm. range should give nearly 3 times as many as the 8.2 cm. α rays. It would appear, according to Chadwick and Bieler, that as a first approximation the α particle behaves in collision with a hydrogen nucleus as a body with properties intermediate between an elastic sphere and an elastic plate, and more like an elastic oblate spheroid of semi axes about 8×10^{-13} cm. and 4×10^{-13} cm., respectively, moving in the direction of its minor axis. On this view a hydrogen nucleus projected towards an α particle would move under the ordinary electrostatic forces governed by the inverse square law until it reached a spheroidal surface of the above dimensions. Here it would encounter an extremely powerful field of force and recoil as from a hard elastic body. The deductions made by Chadwick and Bieler are

[22] Chadwick and Bieler, *Phil. Mag.*, Vol. 42, p. 923, Dec., 1921.

[23] McAulay, *Phil. Mag.*, Vol. 42, p. 892, Dec., 1921.

interesting in that they emphasize the view that in dealing with collisions between α particles and hydrogen nuclei one must recognize that the inverse square law of repulsion ceases to hold in the immediate neighborhood of the electric charges carried by these nuclei. What the law of variation of the electric force is very close to an electric charge such as we have in an α particle can not as yet be deduced from the experimental evidence available. It is clear, however, that the electric forces in this region are of great intensity.

It is of interest to note that Chadwick and Bieler have pointed out that their experiments provide the only direct evidence we have as to the size of electrons. Assuming an α particle to consist of 4 protons and 2 nuclei it can be seen that the dimensions of the model of the α particle which their experiments have led them to put forward require that the radius of an electron cannot be greater than about 4×10^{-13} cm. Hitherto the only information we have had available as to the dimensions of the electron has been that obtained by calculations based on the assumption that its mass is wholly electromagnetic. Such calculations have given the value 2×10^{-13} cm. for its diameter. While it is clear that an inverse square law of force does not hold in the region extremely close to a nucleus, the experiments of Geiger and Marsden on the angular scattering of alpha particles by gold atoms between 5° and 150° show that it does hold very closely for distance, between 3.1×10^{-12} cm. and 36×10^{-12} cm. from the center of nuclei such as those of gold atoms. In this connection it will be recalled that the agreement between the experimental measurements of the X-ray K series spectra and the theoretical values of Debye[24] and Kroo[25] shows that the inverse square law still holds at the K ring of electrons. In the case of platinum the radius of the K-ring is about 10^{-10} cm. Thus measured from any point in the region between 3×10^{-12} cm. and 10^{-10} cm. from the nucleus of a heavy atom like gold or platinum, the nuclear charge is equal to the atomic number

[24] Debye, *Phys. Zeit.*, XVIII, p. 276, 1917.

[25] Kroo, *Phys. Zeit.*, XIX, p. 307, 1918.

and the law of force is the inverse square. We may therefore conclude that no electrons are present in the region between the nucleus and the K ring.

This result is of special importance in connection with observations recently made by Barkla[26] and White and confirmed to a certain extent by Crowther,[27] which point to the possibility of stimulating atoms to emit radiations of wavelengths shorter than those of any of the known K-series. If these experiments should be corroborated by the results of later work it would appear that we must conclude that these J-rays and possibly, too, the more penetrating gamma rays originate within atomic nuclei and are not produced by disturbances of any of the systems of electrons situated within the atoms but outside their nuclei. In this connection it should be pointed out that Richtmyer[28] has failed to find any valid evidence of the existence of X-rays of the J type.

VII. The Structure of the Nucleus

(*a*) H. particles.

The study of isotopes which we have briefly outlined above has led to very definite views regarding the structure of atomic nuclei. It is clear that all nuclei must be made up of protons and electrons held together by intense fields of force. Direct experimental evidence in support of this view has recently been brought forward by Rutherford[29] and those associated with him.[30] It is found that when swift alpha particles are made to pass through air or nitrogen a few particles having all the properties of protons are projected forward with velocities which give them a maximum range in air of 40 cm. No such long range particles are observed in oxygen or carbon dioxide. When swift alpha particles are made

[26] Barkla and White, *Phil. Mag.* (6), XXXIV, p. 270, 1917.

[27] Crowther, *Phil. Mag.*, (6), Vol. 42, p. 719, Nov., 1921.

[28] Richtmyer, *Phys. Rev.*, p. 433, March, 1921.

[29] Rutherford, Bakerian Lecture, Proc. Roy. Soc. (London), A., Vol. 97, p. 375, 1920.

[30] Rutherford and Chadwick, *Phil. Mag.*, S. 6, Vol. 42, p. 809, Nov., 1921.

to pass through hydrogen the maximum range obtainable for the recoil of hydrogen nuclei is never greater than the equivalent of 29 cm. in air. This makes it clear that the recoil of H particles or protons obtained with nitrogen can not arise from the presence of hydrogen as an impurity in the gas. The H particles must therefore originate in the nuclei of the nitrogen atoms which must therefore suffer disintegration under the intense bombardment of the alpha rays. Results similar to those obtained with nitrogen have been obtained with other elements that have been examined but it is of interest to note that it is only those elements whose atomic mass is given by $4n+2$ or $4n+3$ where n is a whole number that give rise to H particles. Elements of mass 4n like carbon, oxygen and sulphur show no effect. In Table III the results obtained so far are summarized.

TABLE III

RECOIL H PARTICLES AND THEIR RANGES

Element	Mass	$4n+2$ or $4n+3$	Maximum range in cm. of air of H particles or protons expelled under alpha ray bombardment
Boron	11	$2\times4+3$	Ca 45
Nitrogen ..	14	$3\times4+3$	40
Fluorine ..	19	$4\times4+3$	40
Sodium	23	$5\times4+3$	42
Aluminium	27	$6\times4+3$	90
Phosphorus	31	$7\times4+3$	65

(*b*) Ranges of H particles.

With aluminium it will be seen the range of the expelled protons is more than twice as great as for those liberated from nitrogen.

The number of H particles expelled from the nuclei of the atoms of different elements is found to vary greatly with the speed of the impinging alpha rays. When alpha particles from thorium C which have a range of 8.2 cm. in air are used the H particles are relatively numerous. With α particles having a 7 cm. range in air, *i. e.,* those emitted by Ra.C, the number of H particles ejected is considerably smaller. With alpha rays of range 5 cm. in air the number is exceedingly small. With aluminium no H particles appear to be released by alpha particles of range less than 5 cm.

(*c*) H particle satellites: backward recoil.

In experiments with aluminium foils bombarded by alpha rays it was found that the direction of escape of the H particles was to a large extent independent of the direction of the impinging alpha particles. Nearly as many were expelled in the backward as in the forward direction. The maximum range for H particles ejected in the backward direction was, however, found to be less than that of H particles projected forwards. In the case of the former the maximum range was 67 cm. while with the latter it was 90 cm. air equivalent.

In order to explain the ejection of H particles in all directions Rutherford and Chadwick have put forward a simple explanation. They suppose that in such an atom as that of nitrogen the main nucleus has a mass 12 and that it has two H particles moving in an orbit round and close to it. The manner in which the collisions are supposed to occur is shown in Fig. I.

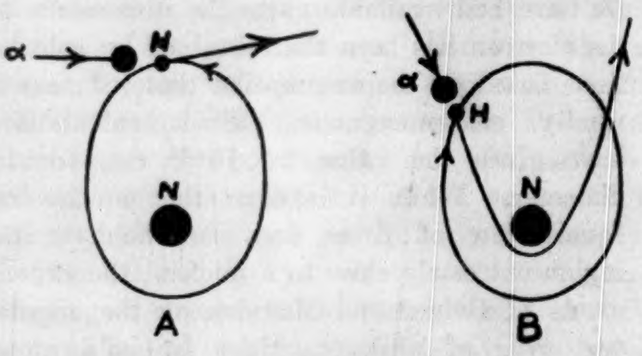


FIG. 1

If the collision occurs as in A the H particle is driven in the forward direction of the alpha particle and away from the nucleus; if, as in B, the H particle is driven towards the nucleus; it describes an orbit close to the latter and escapes in a backward direction. The difference in the velocity of the H particles in the forward and backward directions is probably due to the fact that the main nucleus has been set in motion, in the direction of the alpha particle, before the close collision with the H particle occurs. On this view the relative velocity of the H particle and the residual nucleus is the same whether the H particle escapes in the backward or forward direction, but the actual velocity in the backward direction is less.

(*d*) Attraction between positive charges.

This explanation, it will be noted, implicitly assumes that positively charged bodies attract one another at the very small distances involved in the close collisions between alpha particles and atomic nuclei. Rutherford and Chadwick have pointed out that in order that the colliding alpha particle may communicate much of its momentum to an H particle satellite the latter must be held by strong forces to the nucleus. If, however, the H satellite is very close to the nucleus the alpha particle may have to communicate a considerable fraction of its momentum to the central nucleus, and the velocity of escape of the H satellite is correspondingly reduced. This for example may be the explanation why the alpha particles from aluminium are ejected at higher speeds than those from phosphorus of higher nuclear charge. In phosphorus the H satellites may move so close to the nucleus that the alpha particle is able to give a smaller share of its momentum to the H satellite than in the case of the more distant satellite of aluminium.

(*e*) Close satellites.

So far no H particles have been obtained with elements heavier than phosphorus. The failure to obtain them with such elements may be due to the fact that the H atoms either move very close to the central nucleus or are incorporated in it.

(*f*) Disruption potential.

The theory of nuclear disintegration put forward would seem to demand a definite disruption potential for nuclei having one or more H satellites revolving about them. The experiments with aluminium support this view as no H particles are released from aluminium nuclei by α particles of range in air less than 5 cm. The disruption potential for the nuclei of aluminium atoms, *i. e.*, the potential difference required to communicate the same energy to an electron as is possessed by the α particle is of the order of six million volts. The corresponding potential to liberate an electron from the K or inner ring of electrons of the atoms of aluminium is only about 2,200 volts.

By a simple calculation it can be shown that the results obtained by Rutherford indicate that by operating at six million volts one could with the daily expenditure of 600,000 H.P. disintegrate the nuclei of three cubic feet of nitrogen and obtain thereby not only the recovery of the 600,000 H.P. but also approximately 80,000 H.P. in addition.

(*g*) Atomic weight of nitrogen.

If the view put forward is correct that the H particles are satellites of the central or main nucleus the mass of the H satellite,—since it is not in the "closely packed" condition,—should not be very different from that of a free H nucleus. Assuming that the nitrogen nucleus is derived from that of carbon by the addition of two H satellites and one electron, one might expect the atomic weight of nitrogen to be 14.016, assuming $C = 12.00$, and $H = 1.008$ in terms of $O = 16$. By a slight refinement of Aston's positive ray analysis it should be possible to examine this point.

(*h*) Atomic energy.

A matter of primary importance which has emerged from the experiments on the disintegration of atomic nuclei is that the energy of the H particle as it is ejected from aluminium atoms by the impact of α particles is 1.40 times the energy of the impinging α particles. Even when ejected in a backward direction the released H particle has kinetic energy about 13 per cent. greater than that of the α particle, causing its ejection. This additional energy must come from the atom in consequence of its disintegration. We have therefore in these experiments of Rutherford strong indications of a method of attack which, if followed up, may open a way to the release of the stores of atomic energy existing in ordinary materials about us.

(1) H_3 particles.

In addition to the long range H particles liberated from nitrogen, the passage of α particles through oxygen as well as through nitrogen gives rise to much more numerous swift atoms which have a range in air of about 9 cms compared with that of 7.0 cm. for the colliding α particles. From preliminary observations on these particles they appear to have a mass of 3 and to carry a positive charge 2e. They would thus seem to be the nuclei of an isotope of helium. A number of experiments have been made by Rutherford with α particles traversing gases other than oxygen and nitro-

gen with the object of definitely establishing the origin of these particles. The imperfection of metal foils, used in the experiments, from the point of view of α rays is very great and as yet no very final conclusions can be drawn from the observations. So far, there is always the possibility that these particles may come from the source of α rays. The H_3 particles obtained from nitrogen are from five to ten times as numerous as the H particles so that if these particles really originate in the nuclei of nitrogen atoms, it is clear that the nitrogen nuclei can be disintegrated in two ways and that the two forms of disintegration must be independent and not simultaneous. Since the H_3 and α particles both carry the positive charge 2e, and the range of the former is 27 per cent. greater than that of the latter, it can easily be shown that the H_3 particles have a velocity 20 per cent. greater than that of the α particles. The kinetic energy of the H_3 particles must therefore be about 8 per cent. greater than that of the 7 cm. range α particles. If, therefore, the H_3 particles are ejected from nitrogen nuclei by the α particles there must be a gain of 8 per cent. in energy of motion even though we disregard the subsequent motion of the disintegrated nucleus and of the colliding α particle. It will be interesting to follow developments in connection with these H_3 particles. If their existence be confirmed by future experiments and it can be shown definitely that they originate in the nuclei of atoms of such elements as oxygen and nitrogen, then we shall have in their production a second example of the release of atomic energy through the agency of α rays.

(*j*) Alpha particles.

Attention should be drawn to the branched X-ray cloud tracks recently obtained by Takeo Shimizu[31] by the use of C. T. R. Wilson's beautiful method of making visible the tracks of ionising rays in gases. According to Rutherford if about one hundred thousand α rays from Radium C pass through air, on an average there will be one close nuclear collision which results in the ejection of a swiftly moving H particle. In Shimizu's experiments he found that about one in every three hundred α rays traversing air produce a branched track. These branched tracks cannot therefore have been produced by the ejection of an H particle. One striking feature of the Shimizu branched tracks is that their shapes and sizes are very similar and the lengths of the two limbs of the branches are approximately the same. The angle between the two branches seems to vary but little and judging from the photographs, an example of which taken from Shimizu's paper is shown in Fig. 2, it appears to be about equal to a right angle. With these branched tracks the branching always takes place near the end of the path of the α particle.

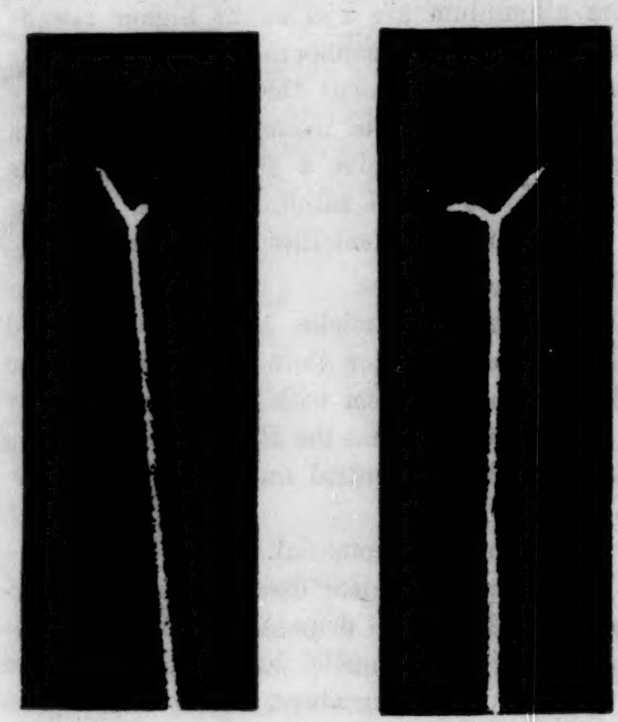


FIG. 2

Photograph of a branched α-ray track viewed from two positions at right angles to each other. Actual magnification 5.5.

In this regard they differ from the short-spurred tracks obtained by C. T. R. Wilson[32] where the abrupt bending of the α ray track took place at different distances from the source of the α particles. In Wilson's experiments the angle between the direction of the short spur and that of the deflected α particle

[31] Shimizu, Proc. Roy. Soc., Series A, Vol. 99, pp. 425 and 432, Aug., 1921.

[32] C. T. R. Wilson, Proc. Roy. Soc., A, Vol. 87, 1912.

was about 107°. This fact, together with the observed relative length of the spur and the track of the deflected α particle seems to show that the spur was due to an oxygen atom recoiling under close impact with the alpha particle. The Shimizu branched tracks, however, appear to be similar to what one would expect to get, on the basis of Darwin's calculations, in a closed collision between an α particle and the nucleus of a helium atom.

This idea naturally suggests that we have in the Shimizu branched tracks examples of the disruption of nuclei with the liberation of He_4^{++} or alpha particles. If this conjecture should turn out to be correct it would indicate that α particles can exist as definite units within the nuclei of atoms of one or more of the gases which make up air. It would be of interest to see if the Shimizu tracks can be obtained in pure nitrogen and also in pure oxygen and other simple gases. Since α particles are known to exist at definite units within the nuclei of the atoms of the radioactive elements, it would not be surprising to find their occurrence in the nucleus of an element such as oxygen. It would be of special interest, however, to find out the lightest atom other than that of helium in the nucleus of which the α particle exists as a unit.

(*k*) Models of atomic nuclei.

It is difficult with the present state of our knowledge to go into details regarding the possible structure of the nuclei of even the lighter and presumably less complex atoms. It would seem, however, that there is strong evidence for the view that among the possible units or structural bricks out of which nuclei are constructed are protons (H_1^+) and α particles (He_4^{++}). There is also some evidence that the particle (He_3^{++}), *i. e.*, the nucleus of a triprotonic isotope of helium can exist as a distinct elementary unit in the nuclei of some types of atom. With such or somewhat similar combining units, attempts have been made by Harkins[33] to work out a constitutional formula applicable to the nuclei of all the elements. The validity of such generalizations can be firmly established only through elaborate and varied experiments, but in the meantime they can at least serve as guides in arranging schemes of attack for prospective experimental work.

A rather suggestive set of models of the atomic nuclei of helium, carbon, nitrogen, and oxygen, based on the ideas of Rutherford is shown in Figs. 3, 4, 5, and 6. In these, the particles H_1^+, He_3^{++} and He_4^{++} are utilized as constituent units. Similar models can be easily made for the nuclei of the atoms of other elements. From these models one would expect to find He_3^{++} particles released by the disruption of carbon atoms, He_3^{++} and H_1^+ particles when nitrogen atoms are broken up and He_4^{++} as well as He_3^{++} particles when oxygen nuclei are disintegrated. It will be seen that the models provide the requisite masses and resultant electric charges for the nuclei they represent. In so far as the nuclei of helium, nitrogen and oxygen atoms are concerned the constitution presented would seem

[33] Harkins, *Phys. Rev.*, Vol. 15, p. 73, 1920.

FIG. 3
HELIUM NUCLEUS

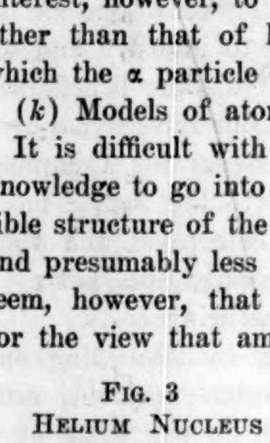


FIG. 4
CARBON NUCLEUS

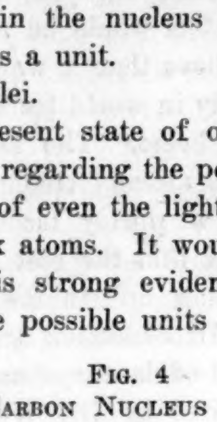


FIG. 5
NITROGEN NUCLEUS

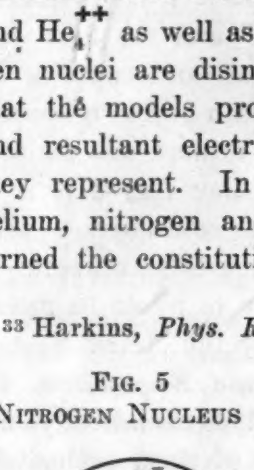
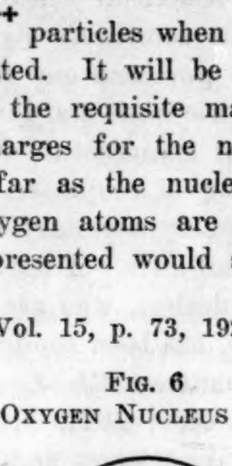


FIG. 6
OXYGEN NUCLEUS



to be not incompatible, at least with the results of many of the experiments of Rutherford and of those who are so brilliantly cooperating with him to reveal to us the ultimate structure of matter.

J. C. McLennan

The Physical Laboratory,
University of Toronto,
December 29, 1921

PROGRESS IN METRIC STANDARDIZATION

Mark Twain remarked that people talked a great deal about the weather and yet he never heard of anybody doing anything about it. The same observation might also be made in reference to the metric system. As scientists we believe in it and through our organizations such as the American Association for the Advancement of Science, the American Chemical Society, etc., we pass resolutions in favor of its adoption, but we do little towards making its use more general. We use the metric system in certain parts of our work but we continue to purchase our chemicals and supplies on the basis of the so-called English "system." The American Chemical Society has resolved to "do something about it" and the first step is to purchase our chemicals and supplies on a metric basis ard thus "clean our own house."

The manufacturers and dealers are entirely willing to cooperate, but they feel that it is absolutely necessary for the consumers to take the initiative. A list of some 40 manufacturers and dealers, who are ready to quote in metric units, has been compiled by the Metric System Committee. *Cf. J. Ind. and Eng. Chem.* 13, 1068 *Nov.* 1921. Several firms already use metric packages and some of them exclusively such as the Eastman Kodak Company, Powers-Weightman-Rosengarten Co., etc.

Users of chemicals are now asked to write their specifications in metric units in order to aid in this movement. Over 300 colleges and universities have already agreed to cooperate in the movement, with only one institution known to be opposed to the change. Over 250 technical firms have agreed to purchase their pure chemicals and chemical supplies in metric packages. Firms have been urged to write to the Committee "even if opposed to the movement." It is significant that less than 3 per cent. of those heard from are opposed, which prompts us to believe that in a short time pure chemicals in America may be packed exclusively in the standard metric packages as recommended by the Committee on Guaranteed Reagents and Standard Apparatus (*cf. J. Ind. Eng. Chem.* May 1921), Dr. W. D. Collins, Chairman.

We now ask that all scientists—physicists, biologists as well as chemists—make a point of ordering chemicals in metric units. It is not practicable to reach by letter all of the teachers of science in our schools and colleges as well as those using chemicals in the industries, hence we are making this general appeal so that the transition period may be made as short as practicable. We have had printed "stickers" stating that "orders must be filled and billed in metric units" which will be sent to any correspondent for the asking.

No scientist would willingly join a movement which would work an injury to American industry. We have considered the question whether the compulsory adoption of the metric system would be injurious to industry and we believe that it would be of distinct benefit not only in world trade but in our intercourse here at home. The DeLaval Separator Company has already changed over to the metric basis in a purely mechanical enterprise and they find that the cost of the change does not even "show up" in the manufacturing costs.

In education the saving by abolishing our out-of-date system would be enormous, estimated by Dr. Wolf to be an aggregate of a million years in a single generation. The promotion of understandings with other nations tends to the promotion of world peace and the cost of not adopting the system used by practically every nation in the world except the English and ourselves may far exceed in a single generation the cost of making the change.

We need local committees to get the metric system properly taught in the schools. Doctors are writing prescriptions in metric units

voluntarily already on a small scale. Systematic effort would doubtless increase their number many fold. The old apothecary weights might be completely abandoned if effort were expended in that direction. Finally, legislation making the use of metric units obligatory would come as a matter of course when the public understood that prejudice and the supposed interest of a few gage manufacturers was keeping us from the only rational system of weights and measures.

EUGENE C. BINGHAM
Chairman, Metric Committee
LAFAYETTE COLLEGE

THE BANDING OF BIRDS

ON the seventeenth of January, 1922, in response to an invitation from Mr. L. B. Fletcher and others interested in the banding of birds, over a hundred ornithologists, licensed bird-banders and candidates for licenses, met at the Boston Society of Natural History Building in Boston and organized a new ornithological society to be known as the New England Bird Banding Association. The meeting was addressed by S. Prentiss Baldwin of Cleveland, Ohio, who, during the last six years, by introducing bird-trapping as a means of banding birds, has done so much to show the scientific possibilities of the work. The Bureau of Biological Survey in Washington was represented by Major E. A. Goldman, who spoke of the bureau's plans in connection with the movement, strongly endorsing the organization of the new association and recommending the formation of other organizations of the same character at appropriate localities in the United States and Canada.

Members of Audubon societies and bird clubs in several states, and of the Nuttall and Essex County Ornithological clubs, and state ornithologists were present at the meeting, as well as a representative of the Canadian game warden service.

At this writing, January 24, 1922, the association has an enrollment of about three hundred members who are scattered over all parts of the territory covered by the organization, namely, New England, Quebec, and the maritime provinces.

The following officers and councilors were elected:

President: Edward H. Forbush, Westboro, Mass.

First vice-president: Dr. Charles W. Townsend, Boston, Mass.

Second vice-president: James MacKaye, Cambridge, Mass.

Corresponding secretary and treasurer: Laurence B. Fletcher, Brookline, Mass.

Recording secretary: Miss Alice B. Harrington, Lincoln, Mass.

Councilors: A. Cleveland Bent, Taunton, Mass.; Dr. John C. Phillips, Wenham, Mass.; John E. Thayer, Lancaster, Mass.; William P. Wharton, Groton, Mass.; Aaron C. Bagg, Holyoke, Mass.; Charles L. Whittle, Cambridge, Mass.

It may be of interest to ornithologists generally to read an outline of the purposes and plans of the new association which has been formed under the stimuli furnished by the national movement, administered by the Bureau of Biological Survey; by the more general appreciation of the scientific aspects of bird banding as shown, in particular, by Mr. Baldwin's recent work; and by the interesting and valuable data already obtained by previous bird-banding operations.

In the beginning it was felt that the somewhat disappointing results secured from bird banding in the United States to date were due to the workers being too scattered and uncoordinated; to a lack of national support of the plan and the too general character of the ornithological problems bird-banding operations were expected to solve.

From a study of the situation we came to believe that we could obtain the best results:

1. By organizing a regional association of bird banders, meaning by this, bringing together a membership from an area possessing one or more migration highways, along which trapping stations could be established to furnish, by intensive attack, fairly speedy answers to certain specific migration problems, thus early demonstrating to members the scientific value of bird banding with the consequent stimulus to continue the work which it is expected will ultimately solve more ornithological riddles, aid in the solution of others and create new problems not now anticipated;

2. By having the members meet together as often as possible to discuss results, methods and

future plans and to gather inspiration from their fellows after the manner of scientific societies generally, in this way using the combined knowledge of the association to advance the work;

3. By appealing for the support of Audubon societies all over the country on the ground that bird banding is a bird-protection movement, since to an important extent it will be possible in the future to substitute an examination of a live bird for the study of a dead one;

4. By ensuring as far as possible the *permanence* of the movement by means of institutional trapping stations operated by or in connection with Audubon societies, natural history societies, bird clubs, departments of ornithology or zoology at colleges and universities, bird sanctuaries, state and national parks, etc., in addition to stations operated by individuals; and

5. By establishing a convenient local depository of all bird-banding records made by members (an exact copy of the same of course being sent to the Biological Survey) in appropriate quarters where they may be studied by members of the association and others.

CHARLES L. WHITTLE

CAMBRIDGE, MASSACHUSETTS

SCIENTIFIC EVENTS

CONFERENCE ON BUSINESS TRAINING OF THE ENGINEER AND ENGINEERING TRAINING FOR STUDENTS OF BUSINESS

THE United States Commissioner of Education is calling a second public conference on commercial engineering on behalf of a committee on commercial engineering appointed by him to investigate business training of engineers and engineering training for students of business.

The conference will be held May 1 and 2 at the Carnegie Institute of Technology in Pittsburgh. President Arthur Hamerschlag of this institution is a member of the committee which is composed of prominent deans of schools of engineering, and of commerce in our larger universities, and of engineers and business men who are nationally known for their interest in the reduction of the costs of production, distribution, transportation, etc., through better training in schools and colleges of the personnel of industry and commerce.

The conference will be open to the public. Invitations to appoint delegates to the Pittsburgh Conference, however, will be sent by the commissioner of education to commercial and trade organizations, engineering and scientific societies, educational institutions and other groups as well as to prominent individuals.

Owing to the timeliness of the subject, the conference in Pittsburgh will even have greater national significance than the first public conference on this question, which was held in Washington two and one half years ago under the direction of this committee on commercial engineering of which Dr. Glen Levin Swiggett of the Bureau of Education is chairman. He says:

The four major topics of the conference will be presented and discussed at general and round table sessions by business men, educators and engineers, contributing to the construction of a cooperative program between education and business for the better coordination of all productive and distributive processes in trade and commerce. It is planned to have the second conference even more constructive than the first, since which time the curricula of 29 of the 119 engineering colleges reporting to the Bureau of Education have been favorably modified to include one or more of the four committee recommendations. Outstanding topics at the Pittsburgh conference will deal with the new problems that have recently arisen in modern industries, the solution of which demands a more scientific approach to include job analyses and personnel specifications and a translation of these into a new and teachable content for use in our engineering and commerce schools; with the training of the engineer for a better understanding of problems relating to community development; and with the training of the engineer for management of overseas engineering projects.

GIFT OF THE ROCKEFELLER FOUNDATION FOR A SCHOOL OF HYGIENE IN LONDON

ACCORDING to a press dispatch to the New York *Times* the British minister of health announced on February 21 that the Rockefeller Foundation had offered to provide $2,000,000 toward the cost of building and equipping a school of hygiene in London. This offer is on the understanding that the British Government

shall accept the responsibility of providing for appointing the staff and maintaining the school when established.

Such a school was recommended by the committee appointed early in 1921 to consider provision for post graduate medical examination in London, and the recommendation was further considered by an expert committee with the minister of health as chairman.

In view of the difficulty at present of financing the scheme, the whole case was presented to the Rockefeller Foundation as one in which it might think it well to cooperate in the general interest of progress in public health.

This gift follows the donation of £1,000,000 to the University of London and University College Hospital.

For providing the staff and maintaining the proposed school of hygiene, the government will have to allocate £125,000 spread over a period of five years. So long ago as 1915, the Institute of Hygiene planned a great central building in Marylebone Road, but the estimate at that date of £47,000 for the building alone made it impossible to proceed. In March of last year a new estimate was obtained and it was found that the cost would approximate £125,000. The British Government felt it impossible to allocate the necessary funds at a period of such financial difficulty as the present.

In June, 1920, the Rockefeller Foundation announced that it had provided endowment yielding £30,000 annually for the University of London to aid medical study. At that time it was said that the funds would be used to support a new staff in anatomy at the college, for an increase in the staff of physiology, for a full-time unit in obstetrics and for various items of increased laboratory and clinical service. In a statement issued at the time of the gift by Dr. George E. Vincent, president of the Rockefeller Foundation, it was said:

Since the Rockefeller Foundation is cooperating with governments in many parts of the British Empire, it recognizes the importance of aiding medical education in London, where the training of personnel and the setting of standards for health work throughout the eimpire are so largely centered.

LECTURES IN CHEMICAL ENGINEERING

IN connection with the recently organized course of chemical engineering at Yale University, a series of lectures has been given during the winter by prominent technologists including:

Dr. H. C. Parmelee, editor of *Chemical and Metallurgical Engineering* (opening lecture, October 19, 1921), "The chemical engineer."

Mr. Fred Zeisberg, of the du Pont Company (October 26), "Manufacture of nitric acid."

Mr. A. E. Marshall, consulting engineer, Baltimore, Md. (November 1), "The manufacture of sulphuric acid and some points in the training of the chemical engineer."

Dr. Bradley Stoughton, consulting engineer, New York City, (December 7), "The rôle of iron and steel as relating to the manufacture and use of chemical equipment and processes."

Mr. L. D. Vorce, consulting engineer (December 15), "The electrolytic production of alkali and chlorine."

Mr. Walter E. Lummus, Walter Lummus Company, Boston, Mass. (January 18, 1922), "Modern methods of fractional distillation."

Dr. C. R. Downs, Barrett Company (January 25), "Distillation of coal-tar products."

Dr. Otto Mantius, consulting engineer, New York City (February 15), "Evaporation and evaporators."

THE SHELDON MEMORIAL

A FEW months ago, as already noted in SCIENCE, the Sheldon Memorial Committee was organized to receive subscriptions toward a foundation in honor of the late Dr. Samuel Sheldon, professor of electrical engineering and physics at the Polytechnic Institute of Brooklyn, 1889-1920.

As chairman of the committee, I am glad to report that we are now turning over to the Treasurer of the Polytechnic Institute $15,018, the sum so far paid in by more than 1,000 subscribers. There are still a few unpaid subscriptions and we are hoping to secure enough further pledges to raise the fund to at least $20,000. Although the sum raised was hardly sufficient really to endow a laboratory, the corporation of the institute has ordered that the Electrical Measurements Laboratory be known hereafter as the Samuel Sheldon Memorial Laboratory of Electrical Measurements and its

members have collected among themselves an additional $1,000 for immediate improvements and the installation of a memorial tablet. In this manner, the entire fund raised by our committee will be invested in the form of a trust and the income used perpetually for the maintenance of this laboratory which will thereby become one of the best laboratories of electrical measurements in the country.

I wish also to note the general sentiments of esteem and admiration expressed toward Dr. Sheldon, the loyalty of several hundred former students to his memory, and the enthusiasm found within the splendid institution to which with such conspicuous success he devoted so many years of his life.

T. C. MARTIN,
Chairman

THE RAMSAY MEMORIAL FELLOWSHIP

THE trustees of the Ramsay Memorial Fund have requested the National Research Council to nominate a fellow to devote his whole time to research in chemistry in some English university upon a stipend of 250 pounds sterling per year, with an additional allowance of 50 pounds for apparatus. The National Research Council has appointed a nominating committee consisting of F. G. Cottrell, chairman of the Division of Chemistry and Chemical Technology, National Research Council, Washington, D. C.; E. B. Mathews, chairman of the Division of Geology and Geography, National Research Council, Washington, D. C., and professor of mineralogy and petrography, Johns Hopkins University, Baltimore, Md.; and W. E. Tisdale, secretary of the Division of Physical Sciences, National Research Council, Washington, D. C.

This committee is willing to receive applications from any American chemists who have taken a degree with distinction in chemistry in a university or college within the United States, and who are now connected with a university or college, or have recently been graduated therefrom.

The appointment will be for the academic year 1922-1923, and the fellow is eligible for reappointment for a second year.

Applicants should furnish:

1. Certificates or other satisfactory evidence of birth, health, character, and academic or other distinctions.

2. A written application stating:

(*a*) Education and employment to date, and particularly the nature, extent, and place or places of his academic studies and research.

(*b*) Particulars of the work and place of work proposed; and

(*c*) The names and addresses of not more than three references well acquainted (one or other of them) with the health, character, capacity and career of the applicant, without, however, any written testimonials from them or others. One of the references should be a teacher under whom the candidate has studied, or a high official of his university, college, or other place of education.

These fellowships are open in chemistry, either pure or applied, and work may be carried on at any university, college, or other place of higher education, or an industrial laboratory within the British Empire. Their object, in this instance, has, in addition to the stimulation of research, the special earnest desire on the part of English scientists to cultivate the wider acquaintance and good fellowship which is so much to be desired between scientific men of the world.

The Ramsay Memorial Fund for research in chemistry within the British Empire was founded in 1920 to commemorate the services to chemistry of Professor Sir William Ramsay, K.C.B., F.R.S., with an initial endowment of £14,000. Since that time several special endowments have established additions to this fund, and special fellowships with appropriate regulations are granted under: The Glasgow Special Fund; Royal Hellenic Government Special Fund; Federal Government of Switzerland and of Swiss Subscribers Special Fund; Royal Italian Government Fund; Fund of the Honorary Advisory Council for Scientific and Industrial Research, Canada; Royal Swedish Government Special Fund.

Applications should be mailed before April 15 to

W. E. TISDALE,
Secretary

1701 MASSACHUSETTS AVENUE,
WASHINGTON, D. C.

SCIENTIFIC NOTES AND NEWS

DR. VERNON KELLOGG, zoologist, secretary of the National Research Council, Washington, D. C., and John W. Davis, attorney, of New York City, formerly ambassador to Great Britain, have been elected trustees of the Rockefeller Foundation.

PROFESSOR JOHN MERLE COULTER, head of the department of botany at the University of Chicago and editor of the *Botanical Gazette*, has been elected a corresponding member of the Czecho-Slovakian Botanical Society.

COLONEL ARTHUR S. DWIGHT, of New York, was elected president of the American Institute of Mining and Metallurgical Engineers, at the annual meeting in New York City held last week.

MR. E. T. NEWTON, formerly paleontologist to the British Geological Survey, has been elected president of the Paleontographical Society in succession to the late Dr. Henry Woodward.

WE learn from the *Journal* of the American Medical Association that the University of Würzburg has awarded the Schneider prize for the best work on tuberculosis during the last ten years to Professor K. E. Ranke of the University of Munich. The award states that by his anatomic research on the primary complex and the secondary phase of tuberculosis, clinical understanding of the beginnings of tuberculosis has been deepened, and a basis of pathological anatomy provided for recognition of the incipient disease.

DR. ADOLPHO LINDENBERG, of the Faculty of Medicine and vice-president of the Society of Medicine, has been elected president of the Society of Biology recently founded in São Paulo, Brazil.

PHILIP SEABURY SMITH has resigned as chief of the Latin-American division of the Bureau of Foreign and Domestic Commerce to become associate editor of *Ingenieria Internacional*.

CAPTAIN A. W. FUCHS, formerly of the U. S. Public Health Service, has resigned to become sanitary engineer for the Missouri Pacific Railroad, with headquarters at Memphis, Tenn.

DR. HERBERT S. DAVIS, until recently professor of biology in the University of Florida, has entered the permanent service of the Bureau of Fisheries as fish pathologist. Dr. Davis has during several summers served the Bureau in the capacity of temporary investigator, first at the Beaufort Biological Station and later at the Fairport Biological Station, giving special attention to the parasites and the diseases of fishes.

MR. R. H. HEISING of the engineering laboratory of the Western Electric Company has been awarded the Morris Lieman prize of the Institute of Radio Engineers for the most important contribution to the radio art in the past twelve months. Recently his efforts have been devoted to the study of radio systems for extending Bell telephone service to locations which can not be reached by wire.

DR. S. K. LOY, chief chemist of the Standard Oil Company's refinery at Casper, Wyoming, has been appointed consulting chemist of the Bureau of Mines in connection with oil shale work.

PROFESSOR WILLIAM ERNEST HOCKING, Ph. D., Alford professor of natural religion, moral philosophy and civil polity, and Professor Alfred Marston Tozzer, Ph. D., professor of anthropology, have been appointed the professors from Harvard University for the second half of the year 1922-23 under the interchange agreement between Harvard University and the Western Colleges.

PROFESSOR B. E. FERNOW, formerly head of the College of Forestry, has returned to Ithaca from Toronto, Canada, to make his home with his son, Bernard E. Fernow, Jr., who is an instructor in the College of Mechanical Engineering of Cornell University.

AT the last annual meeting of the American Society of Mammalogists there was authorized the appointment of a Committee on Marine Mammals, with the intention that it should work primarily along the lines of conservation. The committee consists of the following: Dr. E. W. Nelson, chairman, U. S. Biological Survey, Washington, D. C.; Mr. Gerrit S. Miller,

Jr., U. S. National Museum, Washington, D. C.; Dr. T. S. Palmer, U. S. Biological Survey, Washington, D. C.; Dr. Barton W. Evermann, California Academy Sciences, San Francisco, California; Dr. Robert Cushman Murphy, American Museum of Natural History, New York, N. Y.

Professor William M. Wheeler, dean of the Bussey Institution, Harvard University, will give at the Lowell Institute, Boston, a series of lectures on "Social Life Among Insects." The dates and subjects of the individual lectures will be:

February 27: "A comparison of animals and human societies. The social beetles."
March 2: "Wasps, solitary and social."
March 6: "Bees, solitary and social."
March 9: "Ants, their development, castes, nesting, and feeding habits."
March 13: "Parasitic ants and ant guests."
March 16: "Termites, or white ants."

Dr. William K. Gregory, Ph. D., associate professor of vertebrate paleontology at Columbia University and curator of the Department of Comparative Anatomy of the American Museum of Natural History, will deliver on March 4, 11, 18 and 25 at the Wagner Free Institute of Science in Philadelphia, four lectures on "The Evolution of the Human Face."

Professor W. J. Mead, of the department of geology of the University of Wisconsin, gave a course of twelve lectures in metamorphic geology at the University of Chicago during the first half of the winter quarter.

Dr. Woods Hutchinson, of New York, addressed the staff of the Mayo Clinic on January 18; he discussed "Causes of high death rates reported."

Dr. John H. Stokes, of the Mayo Clinic, recently addressed Institutes in Memphis, Tennessee, and Louisville, Kentucky, as a special consultant of the United States Public Health Service.

Dr. Harold Hibbert, of Yale University, addressed the students of the Department of Chemistry of Oberlin College, on February 8, on "Recent work on the constitution of starch and cellulose." On February 10, he lectured to the Syracuse Section of the American Chemical Society on: "The role of alkali in the future development of the cattle-food, cellulose, wood-pulp, and liquid fuel industries," and, on the following day spoke to the graduate students of the department of chemistry of Syracuse University and of the New York State College of Forestry on "A review of recent work on the polysaccharides."

Dr. W. W. Swingle, of the zoology department of Yale University, lectured recently at Mount Holyoke on "The effect of thyroid secretion upon growth and development."

Charles Leonard Bouton, professor of mathematics at Harvard University, died on February 20, aged fifty-three years.

Charles Lewis Taylor, president of the Carnegie Hero Fund Commission and chairman of the Carnegie Relief Fund, died on February 3 in Santa Barbara, California, at the age of sixty-five years. He was prominent as a metallurgist and chemist.

Robert L. Jack, for many years government geologist in Queensland, died at Sydney, New South Wales, in November, at the age of seventy-six years.

Mr. J. Fischer-Hinnen, professor of electrotechnics and director of the Electrotechnic Institute of the Winterthur Technical College, died on January 13, at the age of fifty-two years.

Emile Rivière, well-known for his explorations of paleolithic caves of Mentone and the south of France, died in Paris on January 25, at the age of eighty-six years.

The ninetieth annual meeting of the British Medical Association will be held from July 25 to 29, at Glasgow, under the presidency of Sir William Macewen, F. R. S.

It is proposed to place a bronze memorial tablet to Professor Sheridan Delépine in the Public Health Laboratory at Manchester, and old pupils and friends have been invited to subscribe sums not exceeding one guinea. In connection with the matter a committee has

been formed, including Sir Henry Miers, vice-chancellor of Manchester University; Sir Edward Donner, Dr. Niven, Medical Officer of Health of Manchester; Dr. Brinley, Dr. Slater, Mr. Heap, and Dr. Sidebothan.

A REPORT has been issued of the proceedings of the conference on the problem of the unusually gifted student, called by the Divisions of Educational Relations and of Anthropology and Psychology of the National Research Council. This conference was held on December 23, 1921, and was referred to in SCIENCE of January 20, 1922. A copy of this report in mimeographed form will be sent to any one interested upon application to Dr. Vernon Kellogg, chairman, Division of Educational Relations, National Research Council, 1701 Massachusetts Avenue, Washington, D. C.

WE learn from the London *Times* that the Commonwealth Government will place a warship at the disposal of astronomers who are going to visit the northwest of western Australia in September to observe the total eclipse of the sun on September 21. The apparatus is to be established at Wollal, a lonely point on the coast between Port Hedland and Broome. The party, for whom an observation camp will be created, includes Dr. W. W. Campbell, director of the Lick Observatory, California, and Mrs. Campbell; Dr. Moore and Dr. Trumpler, also of the Lick Observatory; Dr. and Mrs. Adams, of New Zealand; Professor Chant and three assistants from Toronto Observatory, and Australian astronomers. The Naval Meteorological Department is making arrangements for the reception of the visitors. The path of totality will be covered as follows: It begins in Abyssinia, and passes over the center of Italian Somaliland and across the Maldive Islands, where Mr. J. Evershed, director of the Kodaikanal Observatory (India), will be stationed Thence it passes across the Indian Ocean to Christmas Island, the most favorable of the places where observation is feasible. Two expeditions are going there, one a British expedition, from Greenwich, consisting of Mr. H. Spenser Jones, chief assistant, and Mr. P. J. Melotte, the discoverer of the eighth satellite of Jupiter; the other a joint Dutch and German expedition, which Professor Einstein may possibly accompany.

REFERRING to a report from Australia that the southern station of the Harvard College Observatory may be moved from Arequipa, Peru, to Queensland, the *Alumni Bulletin* states that there is no immediate prospect of such a change. An influential member of the Queensland government suggested recently that a site might be found there which would prove more advantageous than Arequipa, and received permission from Harvard to go so far as to have meteorological observations made to determine the conditions for astronomical work in Queensland. No definite offer of a site has been received, however, and it is said to be unlikely that any decision one way or the other will be made for the present.

PROFESSOR HOMER R. DILL, director of the vertebrate exhibit at the State University of Iowa, will conduct an expedition to the South Seas some time next year. The primary object will be the collection of fish, but it is hoped that many birds and small mammals may also be taken. Several months will be spent visiting various islands including the Marquesas, Society, Friendly, Samoan and Fiji groups. Stops may also be made in New Zealand and Japan. Other members of the party will include Mr. E. W. Brown, of Des Moines, who is financing the trip, and his wife and son, Robert Brown. The latter is at present studying under Professor Dill. Mrs. Brown, who has had considerable experience in fish painting, will serve as artist on this trip and make sketches of the different species as they appear in life. A former expedition in 1920 with the same personnel was made to the Hawaiian islands and as a result many species of fish were added to the university collection. The fish will be shipped back to the United States in large tanks which are now being constructed. A new preserving fluid discovered by Professor Dill was found to be satisfactory on the Hawaiian expedition and will be used again on this trip. It retains the natural coloring of the dead fish to a large extent, which is an important factor in the collection of many of the highly colored tropical species.

UNIVERSITY AND EDUCATIONAL NOTES

The Rockefeller Foundation has given six million dollars to Johns Hopkins University for the endowment and buildings of the School of Hygiene and Public Health.

It is planned to establish a forest experiment station in connection with the University of California. There are twenty million acres of forest lands in the state.

The five hundred members of the senior class at the Pennsylvania State College have voted unanimously to give the college $100 each, making a total of $50,000 as their class memorial endowment.

At Yale University the degree of master of science in civil engineering, electrical engineering, mechanical engineering, mining engineering, or metallurgical engineering may hereafter be awarded to holders of a bachelor's degree from a college or technical school of high standing who specialize for at least two undergraduate years in that branch of engineering in which the degree is to be taken.

Dr. M. C. Merrill, professor of horticulture at the Utah Agricultural College, Logan, Utah, has resigned his position at that institution to accept the deanship of the school of applied arts at the Brigham Young University, at Provo, Utah. Dr. Merrill will assume his new work on July 1.

Dr. Horatio B. Williams, assistant professor of physiology in the College of Physicians and Surgeons of Columbia University, has been promoted tc be Dalton professor of physiology.

Dr. Karl Schlaepfer, of the University of Zurich, Switzerland, has been appointed associate in surgery at the Johns Hopkins Medical School. Dr. Ernst Huber, also of the University of Zurich, has been appointed associate in anatomy.

Professor W. H. Davis, of the Iowa State Teachers' College, has been granted a Ph.D. degree by the University of Wisconsin and has assumed his work in mycology and plant pathology at the Massachusetts Agricultural College, Amherst.

Mr. R. W. Palmer, of the Geological Survey of India, has been appointed senior lecturer in geology at the University of Manchester.

DISCUSSION AND CORRESPONDENCE

DUTY ON ENGLISH BOOKS

In a book-importer's catalogue we read:

"It may be noted that all foreign books can be imported free of duty, as well as English books, more than twenty years old at the date of importation."

Such, in fact, is the law of the land; but, in its application we have found grave modifications.

Importing a series of English scientific magazines some months ago we were informed that the shipment was in the hands of an importing or forwarding agency and would be seen through the customs and sent on upon payment for services and duty charges. In compliance with this request an amount covering charges for services and the portion of the series dutiable at the usual fifteen per cent. was forwarded the agency. The books arrived safely, apparently untouched or undisturbed in any way by customs officials. The dutiable portion constituted one fourth the entire shipment. After some time a bill came requesting payment for duty on the remaining three-fourths of the shipment, on that portion of the series printed over twenty years ago. Inquiry elicited the information that duty had been demanded and had been paid by the agency on the whole shipment. Further inquiry established the fact that duty on the whole shipment had been based on a certain precedent where an importer of books had brought in this country an integral "set" of books, some less, some more than twenty years old and that the "set" was looked upon as all dutiable, indivisible. So in the "spirit" of the law our magazines were all dutiable, whatever might be their age or the age of the majority of them. So the law might call, as it did in our case, for a duty of $6.00, but its "spirit" called for $18.00 more.

Conclusion for individual importers: see to it that your foreign exporters do not send you the older and newer numbers of magazines in the same box or shipment.

We can scarcely refrain from suggesting, in the present depleted state of our Treasury Department, that all revenue laws should be constructed for "spirit" attachments.

G. D. HARRIS

CORNELL UNIVERSITY

ALTERNATE BEARING OF FRUIT TREES

IN view of the heightened interest in the alternate bearing of fruit trees and in fruit bud formation it may be interesting to quote the following passage from the *Magazine of Horticulture* for 1847, volume 13, page 438. The note was written by Charles M. Hovey, editor of the magazine, author of several well-known horticultural works, and often called the father of the American strawberry, after a visit to the Pomological Gardens at Salem, Massachusetts, of Robert Manning, one of the most thorough and accurate students of horticulture in the early days when amateur interest in fruits ran high:

> Passing a Baldwin apple tree in full bearing, Mr. Manning stated that it was one on which he tried the experiment of changing the bearing year. It is well known that the Baldwin only bears every other year. To obviate this was the object of Mr. Manning; and, in the spring of 1846, he spent nearly two days in cutting off all the blossoms. It had the desired effect; this year, the tree is completely loaded with fruit. This experiment is valuable, for it shows that, in a large orchard, when the trees, by chance, nearly all fruit the same year, any number of them can be made to fruit in the alternate year simply by the labor of destroying all the blossoms.

HAROLD B. TUKEY

N. Y. AGRICULTURAL EXPERIMENT STATION,
GENEVA, NEW YORK

THE WRITING OF POPULAR SCIENCE

TO THE EDITOR OF SCIENCE: In looking through the "List of One Hundred Popular Books in Science" prepared by the Washington Academy of Sciences for the guidance of libraries with limited income, one is struck by the number of foreign books. There are thirty-five British authors, two French (Fabre and Maeterlinck) and one German (Einstein); that is, in searching for the best books on the various sciences, regardless of nationality, it was found necessary to go abroad for 38 per cent. of them.

This is curious since in writing for American readers an American author has a decided advantage in that he understands their point of view and can use more or less local illustrations and comparisons and make allusions to familiar things, which are important factors in the popular presentation of scientific questions.

In spite of this natural handicap on the foreign author, British books form more than a third of this carefully selected list, so it is evident that the British are doing better work in the popularization of science than we are, a conclusion that is confirmed by a comparison of imported and domestic books in publishers' catalogues. We have in this country, for instance, nothing to compare in style of writing and attractive illustrations with the "Outline of Science" edited by Professor J. Arthur Thomson, which is now being published in parts at 1 shilling, 2 pence, as was Wells' "Outline of History." I may add that Science Service, which has been scouring the country for a year for popular science writers, has been obliged to go to England for them in many cases.

This is difficult to account for since our American schools give much more attention to the sciences and to the teaching of English composition than do the British schools and since we have such an abundance of fluent and facile writers in fiction and journalism and since we have a wider reading public than any other country. But it is questionable whether the interest of the American people in scientific questions has kept pace with the growing importance of science in human life. In fact some say that science is losing ground in popular esteem. For instance, Dr. Alfred H. Brooks, of the U. S. Geological Survey, said in his recent presidential address to the Washington Academy of Sciences:

> I venture the opinion that there is to-day relatively less popular knowledge of science and less interest in its methods and achievements than there was a generation ago.

This is a discouraging statement in view of

the unprecedented expenditure of money on scientific education in American schools.

EDWIN E. SLOSSON

SCIENCE SERVICE,
WASHINGTON, D. C.

QUOTATIONS

WILLIAM JENNINGS BRYAN ON EVOLUTION[1]

THE only part of evolution in which any considerable interest is felt is evolution applied to man. A hypothesis in regard to the rocks and plant life does not affect the philosophy upon which one's life is built. Evolution applied to fish, birds and beasts would not materially affect man's view of his own responsibilities except as the acceptance of an unsupported hypothesis as to these would be used to support a similar hypothesis as to man. The evolution that is harmful—distinctly so—is the evolution that destroys man's family tree as taught by the Bible and makes him a descendant of the lower forms of life. This, as I shall try to show, is a very vital matter.

* * * * * *

The latest word that we have on this subject comes from Professor Bateson, a high English authority, who journeyed all the way from London to Toronto, Canada, to address the American Association for the Advancement of Science the 28th day of last December. His speech has been published in full in the January issue of SCIENCE.

Professor Bateson is an evolutionist, but he tells with real pathos how every effort to discover the origin of species has failed. He takes up different lines of investigation, commenced hopefully but ending in disappointment. He concludes by saying, "Let us then proclaim in precise and unmistakable language that our faith in evolution is unshaken," and then he adds, "our doubts are not as to the reality or truth of evolution, but as to the origin of species, a technical, almost domestic problem. Any day that mystery may be solved." Here is optimism at its maximum. They fall back on faith. They have not yet found the origin of species, and yet how can evolution explain life unless it can account for change in species? Is it not more rational to believe in creation of man by separate act of God than to believe in evolution without a particle of evidence?

* * * * * *

The objection to Darwinism is that it is *harmful,* as well as groundless. It entirely changes one's view of life and undermines faith in the Bible. Evolution has no place for the miracle or the supernatural. It flatters the egotist to be told that there is nothing that his mind cannot understand. Evolution proposes to bring all the processes of nature within the comprehension of man by making it the explanation of everything that is known. Creation implies a Creator, and the finite mind cannot comprehend the Infinite. We can understand some things, but we run across mystery at every point. Evolution attempts to solve the mystery of life by suggesting a process of development commencing "in the dawn of time" and continuing uninterrupted up until now. Evolution does not explain creation; it simply diverts attention from it by hiding it behind eons of time. If a man accepts Darwinism, or evolution applied to man, and is consistent, he rejects the miracle and the supernatural as impossible. He commences with the first chapter of Genesis and blots out the Bible story of man's creation, not because the evidence is insufficient, but because the miracle is inconsistent with evolution. If he is consistent, he will go through the Old Testament step by step and cut out all the miracles and all the supernatural—the virgin birth of Christ, His miracles and His resurrection, leaving the Bible a story book without binding authority upon the conscience of man.

* * * * * *

Christians do not object to freedom of speech; they believe that Biblical truth can hold its own in a fair field. They concede the right of ministers to pass from belief to agnosticism or atheism, but they contend that they should be honest enough to separate themselves from the ministry and not attempt to debase the religion which they profess.

And so in the matter of education. Christians do not dispute the right of any teacher to be agnostic or atheistic, but Christians do deny

[1] From an article in the New York *Times* for February 25. The editor states that Mr. Bryan will be answered by Professor Henry Fairfield Osborn and Professor Edwin Grant Conkin in the issue for March 2.

the right of agnostics and atheists to use the public school as a forum for the teaching of their doctrines.

The Bible has in many places been excluded from the schools on the ground that religion should not be taught by those paid by public taxation. If this doctrine is sound, what right have the enemies of religion to teach irreligion in the public schools? If the Bible cannot be taught, why should Christian taxpayers permit the teaching of guesses that make the Bible a lie? A teacher might just as well write over the door of his room, "Leave Christianity behind you, all ye who enter here," as to ask his students to accept an hypothesis directly and irreconcilably antagonistic to the Bible.

Our opponents are not fair. When we find fault with the teaching of Darwin's unsupported hypothesis, they talk about Copernius and Galileo and ask whether we shall exclude science and return to the dark ages. Their evasion is a confession of weakness. We do not ask for the exclusion of any scientific truth, but we do protest against an atheist teacher being allowed to blow his guesses in the face of the student. The Christians who want to teach religion in their schools furnish the money for denominational institutions. If atheists want to teach atheism, why do they not build their own schools and employ their own teachers? If a man really believes that he has brute blood in him, he can teach that to his children at home or he can send them to atheistic schools, where his children will not be in danger of losing their brute philosophy, but why should he be allowed to deal with other people's children as if they were little monkeys?

We stamp upon our coins "In God We Trust"; we administer to witnesses an oath in which God's name appears; our President takes his oath of office upon the Bible. Is it fanatical to suggest that public taxes should not be employed for the purpose of undermining the nation's God? When we defend the Mosaic account of man's creation and contend that man has no brute blood in him, but was made in God's image by separate act and placed on earth to carry out a divine decree, we are defending the God of the Jews as well as the God of the Gentiles; the God of the Catholics as well as the God of the Protestants. We believe that faith in a Supreme Being is essential to civilization as well as to religion and that abandonment of God means ruin to the world and chaos to society.

Let these believers in "the tree man" come down out of the trees and meet the issue. Let them defend the teaching of agnosticism or atheism if they dare. If they deny that the natural tendency of Darwinism is to lead man to a denial of God, let them frankly point out the portions of the Bible which they regard as consistent with Darwinism, or evolution applied to man. They weaken faith in God, discourage prayer, raise doubt as to a future life, reduce Christ to the stature of a man, and make the Bible a "scrap of paper." As religion is the only basis of morals, it is time for Christians to protect religion from its most insidious enemy.

SCIENTIFIC BOOKS

James Hall of Albany, Geologist and Palæontologist, 1811-1898. By John M. Clarke. Pp. 565, illustrated. Albany, 1921 (S. C. Bishop, $3.70, net).

In this book we have a very informative and highly entertaining history, not only of Professor James Hall, but of most of the other pioneers in American geology and paleontology as well. It is replete with interest for all men of science.

Hall was an extraordinary man in many ways, turning out a prodigious amount of geologic work, and furnishing, by his dynamism, an inestimable "creative impulse to study and research." He was sensitive to a remarkable degree, irascible, and with a surpassing ambition. His nervous system always taut, he "played on a harp of a thousand strings." In consequence he appears to have been in trouble with most of his associates, and yet he was "a confiding man, forever trusting the plausible stranger, even while distrusting his most devoted friends." He lost much money in mining!

Hall's scientific career began in 1836 and for sixty-two years he dominated Paleozoic geology, and more especially paleontology, in

North America. Thirteen great quarto volumes and at least a five-foot shelf of works on paleontology are his enduring monuments.

The wonderful Fourth District of western New York was Hall's "patent" and in it he labored for five years unraveling its geology, "the most excellent piece of field work he ever did," in the course of which was established a large part of the New York System of geological formations. Then came the ever widening *Palæontology of New York,* the dominant note of Hall's long life. An insatiable collector, without ever knowingly having a duplicate fossil, he sold the worked-up collections only to buy and collect others with the money so obtained. Appropriations or none by New York or other states, he went on constantly garnering more material.

As one reads the book, the thought comes readily that New York State has been the mother of geologists—one almost comes to the belief that all American geologists between 1843 and 1890 came from the Empire State or got their training there. We also see the passing show of the master minds that developed the geology of the entire Mississippi Valley, since they were all for one reason or another worshippers at the Albanian shrine. "His influence guided official geologic movements in every state where they were inaugurated, and in many his hand took a helmsman's part." Hall's influence was also great in Canada between 1843 and 1869, since his relations with the director of the Geological Survey of Canada, Sir William Logan, "were openly harmonious."

Hall's zenith of scientific attainments came between 1857 and 1861. Some years before, he presented at the Montreal meeting of the American Association for the Advancement of Science his "most notable performance in philosophical geology," *The Geological History of the North American Continent.* In this essay, published in 1861, he set forth two essential propositions in regard to mountain making, and they are the fundamentals on which our modern conception of these structures depends. These are:

1. That ranges of folded mountains exist only where sediments have uniformly accumulated to maximum thickness and that such maximum accumulation is possible only by corresponding depression of the sea bottom along the edges of continents delivering such sediments. . .

2. That folded mountains result from the crumpling of the upper layers only of these accumulated deposits, a consequence of the adjustment of the later sediments to a deepening but contracting depression.

When Hall was sixty years of age, he was "at the threshold of his greatest productiveness," and he worked in this way:

Of all the corps of men engaged upon this work, Mr. Hall himself was, in these days, the most diligent. Nothing that entered into his publications escaped his criticism and review and he was keen and quick in the preparation of his manuscript. Up and at his desk soon after break of day, with a cup of tea and a panada at his elbow, he found his quiet hours before his assistants came around. And after they had gone there were the evening hours which seldom found him away from his work room. It was his habit when at work to sit before his desk on a revolving piano-stool; his backbone needed no support and an easy chair he abhorred. But alongside his desk he kept, for his callers, a deep scoop-shaped great chair into which the visitor shriveled as he sank down into insignificance near the floor, while his vis-à-vis, erect on his stool, towered majestically over him. It was a strategic advantage and in many an engagement commanded the enemy's works.

When the reviewer went to Albany in 1889 as Hall's private assistant, the latter was a picturesque old man:

His round, full-bodied figure, his heavy snowy beard running well up over his ruddy cheeks, an always erect carriage and a square level look out from under thick brows and over his Moorish nose; dressed in an old coat and in trousers which buttoned down the sides after the fashion of 1830, he was bound to attract attention and curiosity. Every morning . . . his man Tom drove him from his home in a broken-down, one-seated cart which had once owned a top but lost it long since, drawn by a broken-down old nag which had also seen better days and had like as not been taken in exchange for apples or old specimen boxes, his capacious snow-crowned figure capped with a chimney-pot hat towering above his diminutive driver—the jogging figure through the Albany streets was sure to compel notice.

Extolled by LeConte as the "founder of American geology," and by McGee as the "founder of American stratigraphy," said by Dana to be the man without whom "the geological history of the North American continent could not have been written," Hall's present biographer concludes that he "was in truth the apostle of historical geology." Much praise is due Dr. Clarke for the lively way in which he sets Hall—and many of his contemporaries—before us in these pages. The task was a great one, attended with peculiar difficulties, and its accomplishment reflects high credit upon the author. The paleontologic sun rose in New York in 1836, and its warmth still radiates from the Empire State throughout the North American continent!

CHARLES SCHUCHERT

SPECIAL ARTICLES

THE SYNTHESIS OF FULL COLORATION IN PHLOX

IN the issue of *Genetics* for March, 1920, the writer published facts bearing on the color of the flower blade in *Phlox Drummondii.* Certain F_1 purples that were full-colored and self-colored appeared as the progeny of two plants whose blades were a clear white. These F_1 purples, when self-pollinated, gave rise to an F_2 group comprising several types of corolla. A bluing factor in heterozygous condition in the F_1 individuals doubled the number of F_2 colored sorts. Ignoring the differences caused by this factor there were in the F_2 group the following general types (illustrated in colors in Plate 1 in *Genetics,* Vol. 5):

1. Showy full-colored purple or rose type resembling the F_1. The color is evenly suffused over the blade, *i. e.,* the blade is self-colored.

2. A lighter type whose color is bright pinkish or light purplish. This kind also has its color uniformly suffused over the blade.

3. Dusky type whose dull magenta color is merely stippled on to the blade giving the flower the appearance of a dusty or dirty-looking white.

4. Pure white-bladed type.

Proceeding to the F_3 generation it was found that the lighter uniformly colored Type 2 never gave rise to duskies (Type 3) on inbreeding, nor did the duskies ever contain plants of Type 2 among their offspring. Moreover, neither of these two types, on self-pollination, ever produced Type 1. The deep-colored F_2 plants of Type 1 were capable of throwing out Types 2 and 3 besides repeating themselves. Such analysis led to the hypothesis that full or deep coloration in *Phlox* must be due to the presence together of the second and third types, or rather to the genes for these two types, which are not allemorphic.

During the past year this hypothesis was tested out by the actual putting together, through hybridization, of Types 2 and 3. In all, seven matings of Types 2 and 3 were made yielding 59 offspring and from every crossing the progeny were both full-colored and self-colored.

$$\text{Type } 2 + \text{Type } 3 = \text{Type } 1.$$

This synthesis supplements and confirms the author's earlier work on the genetic relationship of color types in *Phlox Drummondii.*

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THE PROPOSED FEDERATION OF BIOLOGICAL SOCIETIES

A CONFERENCE of officers of a number of biological societies was held in Toronto on December 27, 1921, to discuss the feasibility of closer cooperation among these societies. This conference was the outgrowth of two somewhat informal meetings in Chicago, the first in December, 1920, upon the initiative of the secretary of the American Society of Naturalists, the second in April, 1921, at the instance of the officers of the American Society of Zoologists and of the Botanical Society of America. At the request of those in attendance at the second conference the call for the Toronto meeting was issued by the Division of Biology and Agriculture of the National Research Council. The discussion of the Toronto conference was in a measure directed in accordance with a program arranged by the chairman of the Division

of Biology and Agriculture, in consultation with the secretaries of the American Society of Naturalists, the Botanical Society of America, and the American Society of Zoologists. Under the chairmanship of Professor L. R. Jones, the following topics were developed:

I. The federation of biological societies; the idea and possible plans for its realization: C. A. Kofoid, C. E. Allen, F. R. Lillie.

II. Some of the biological problems which federation may help to meet:

1. The needs in the field of genetics: R. A. Emerson, L. J. Cole.
2. Society publications: J. R. Schramm.
3. Correlation of meetings and programs: A. F. Shull, W. C. Allee.

These speakers, and other members of the conference in informal discussion, developed a variety of ways in which a federation or some form of cooperation would aid in the solution of problems that are now pressing. It was urged that more adequate outlets for publication might thereby be provided; that larger editions of larger publications could be published more cheaply than the present small journals with limited circulation; that abstracting, which is very inadequately done for zoological literature, could thus be fostered; that biology could thereby be popularized and given more influence in everyday affairs; that correlation of programs, with respect to place and time, would be rendered less difficult; that programs could be arranged around the larger biological principles, rather than under the headings Botany and Zoology; that formation of new societies or organizations could be initiated or given direction; and that adjustment to changes in the grouping of interests, such as that now presented in the field of genetics, would be facilitated.

It was evident from the discussion that the general idea of federation was practically unanimously approved by the conference, and the following resolutions were adopted:

RESOLVED, 1. That it is the sense of this meeting that the inter-society conferences should be continued to consider the feasibility of federation of the biological societies and to develop plans for the said federation; and

2. That for the purpose of advancing these plans each society, as well as Sections F, G and O of the American Association for the Advancement of Science, be requested to designate its president and secretary as members of an inter-society council which shall be authorized (1) to deal with all matters of common interest, such as coordination of programs, that are consistent with the existing regulations of the constituent societies; and (2) to draw up proposals for a constitution and by-laws of a federation of the societies in question, and to present them for action at the next annual meeting.

Considerable discussion arose as to the details of the proposed federation of societies, but it was realized that these could not be effectually determined in a single brief meeting, and it was decided to leave these matters to the inter-society council provided for in the resolutions. Plans were made for securing prompt action upon the resolutions by all biological societies in session at Toronto and it was informally understood that the proposed council might invite representatives of other sections of the American Association or of other societies if it so desired.

A further resolution was adopted, requesting the Division of Biology and Agriculture to call the first meeting of the proposed inter-society council at a date sufficiently early to admit of deferred meetings and the completion of a plan of federation before the next annual meeting of the societies. The first meeting will probably be called in April.

The organizations represented in the conference at Toronto were as follows: American Society of Zoologists, American Genetic Association, American Society of Naturalists, American Phytopathological Society, Ecological Society of America, Botanical Society of America, American Society for Horticultural Science, Society of American Foresters, Society of American Bacteriologists, American Association of Economic Entomologists, American Society of Agronomy, Entomological Society of America, Sections F, G and O of the American Association for the Advancement of Science, and the Division of Biology and Agriculture of the National Research Council.

A. FRANKLIN SHULL,
Secretary of the Conference